

Respiration in Plants — Assignment 2

Class 11 Biology · Higher-difficulty challenge set + integrated problems · Answer key included · Narayan Gurukul Academy

Instructions: (1) Attempt all questions; start with the topic-wise challenge set, then attempt the integrated (multi-topic) problems.
(2) Give all answers with correct SI units. $g = 10 \text{ m/s}^2$ unless stated.
(3) A final answer key is provided at the end — try the full set before checking it.

Part A — Topic-wise challenge questions

Overview of Cellular Respiration

1. Distinguish between aerobic and anaerobic respiration.
2. State the overall equation of aerobic respiration.
3. Describe the overview of cellular respiration.

Glycolysis (EMP Pathway)

1. State two features of glycolysis.
2. Why is glycolysis called the EMP pathway?
3. Describe the steps of glycolysis.

Fermentation

1. Distinguish between alcoholic and lactic acid fermentation.
2. Why is the energy yield of fermentation low?
3. Describe fermentation with examples.

Link Reaction and Krebs Cycle (TCA Cycle)

1. What is the link reaction?
2. State two products of the Krebs cycle.
3. Describe the link reaction and Krebs cycle.

Electron Transport System and Oxidative Phosphorylation

1. State the role of oxygen in the ETS.
2. What is the chemiosmotic hypothesis?
3. Explain oxidative phosphorylation and the role of ATP synthase.

Respiratory Balance Sheet

1. State the ATP yield of aerobic respiration.
2. Distinguish between substrate-level and oxidative phosphorylation.
3. Prepare a balance sheet of aerobic respiration.

Respiratory Quotient (RQ)

1. How is RQ calculated?
2. Why is the RQ of organic acids more than 1?
3. Explain the respiratory quotient with examples.

Part B — Integrated problems (multi-topic)

1. Describe glycolysis, stating its site, reactants and products.
2. Distinguish between aerobic respiration and fermentation with reference to ATP yield.
3. Describe the link reaction and the Krebs cycle.
4. Explain the electron transport system and oxidative phosphorylation.
5. Prepare the balance sheet of aerobic respiration of one glucose molecule.
6. Define respiratory quotient and give its value for carbohydrate, fat and organic acid respiration.

Answer Key

Overview of Cellular Respiration

Aerobic respiration uses oxygen and completely oxidises glucose; anaerobic respiration occurs without oxygen and is incomplete. Overall: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$. Respiration involves glycolysis (cytoplasm), the link reaction and Krebs cycle (mitochondrial matrix) and the ETS (inner mitochondrial membrane).

Glycolysis (EMP Pathway)

Features: occurs in the cytoplasm, is common to aerobic and anaerobic respiration and yields 2 ATP and 2 NADH per glucose. It is called the EMP pathway after Embden, Meyerhof and Parnas. Glucose is phosphorylated and split into two triose phosphates, which are oxidised to two molecules of pyruvic acid, with a net gain of 2 ATP and 2 NADH.

Fermentation

Alcoholic fermentation: pyruvate $\rightarrow$ ethanol + CO_2 (yeast); lactic acid fermentation: pyruvate $\rightarrow$ lactic acid (muscle, bacteria). Energy yield is low because glucose is only partially oxidised, so only the 2 ATP of glycolysis are produced. In the absence of oxygen, pyruvate is reduced to ethanol and CO_2 (yeast) or to lactic acid (some bacteria and animal muscle).

Link Reaction and Krebs Cycle (TCA Cycle)

The link reaction is the oxidative decarboxylation of pyruvate to acetyl-CoA. Products of the Krebs cycle: NADH, $FADH_2$, ATP (GTP) and CO_2 . Pyruvate is converted to acetyl-CoA by oxidative decarboxylation, which enters the Krebs cycle by condensing with oxaloacetate to form citrate; per turn the cycle releases 2 CO_2 and produces 3 NADH, 1 $FADH_2$ and 1 ATP.

Electron Transport System and Oxidative Phosphorylation

Oxygen is the final electron acceptor, combining with electrons and protons to form water. The chemiosmotic hypothesis states that the proton gradient across the inner membrane drives ATP synthesis. NADH and $FADH_2$ pass electrons to the ETS in the inner mitochondrial membrane; the energy released pumps protons into the intermembrane space, and their return through ATP synthase synthesises ATP (oxidative phosphorylation).

Respiratory Balance Sheet

Aerobic respiration of one glucose yields about 38 ATP (or 36 in older accounting). Substrate-level phosphorylation is ATP formed directly by transfer of a phosphate group during glycolysis/Krebs cycle; oxidative phosphorylation is ATP

formed via the ETS and chemiosmosis. Glycolysis: 2 ATP + 2 NADH; link reaction: 2 NADH; Krebs cycle: 2 ATP + 6 NADH + 2 FADH₂; ETS converts the NADH/FADH₂ to ATP — total about 38 ATP.

Respiratory Quotient (RQ)

RQ = CO₂ released / O₂ consumed. Organic acids have RQ > 1 because they are rich in oxygen and require less external O₂. Carbohydrates: RQ = 1.0; fats: RQ ≈ 0.7; organic acids: RQ > 1; proteins: RQ ≈ 0.9.

Integrated problems

1: Cytoplasm; glucose → 2 pyruvate; net 2 ATP + 2 NADH. 2: Aerobic — complete oxidation, ~38 ATP; fermentation — partial, 2 ATP. 3: Pyruvate → acetyl-CoA (link); acetyl-CoA + OAA → citrate, releasing 2 CO₂, 3 NADH, 1 FADH₂, 1 ATP. 4: ETS in the inner membrane; protons pumped out, ATP synthase makes ATP. 5: Glycolysis 2 ATP + 2 NADH (→ 6 ATP); link 2 NADH (→ 6 ATP); Krebs 2 ATP + 6 NADH (→ 18 ATP) + 2 FADH₂ (→ 4 ATP) = 38 ATP (theoretical). 6: RQ = CO₂/O₂; carbohydrate 1.0, fat 0.7, organic acid > 1.